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An investigation of the impacts of shrimp bottom trawling on the Bardawil lagoon fisheries, Egypt

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ABSTRACT

The fisheries sector is critical for the Egyptian economy where it provides employment for many rural communities, as well as enhancing food security and export earnings. The Egyptian wild (marine and inland) fish stocks are considered overexploited and should therefore be conducted in a responsible manner. The depleted state of Egyptian wild fish stocks is due to overfishing and increasing degradation of coastal, marine and freshwater ecosystems and habitats, as growing coastal populations exert increasing pressures on natural resources. Bardawil lagoon is one of the most important fishing grounds in Egypt, since it is the least polluted lagoon in Egypt and in the whole Mediterranean as well as the majority of fish species were exported. Introducing bottom trawling into this shallow lagoon by 1995 has been completely altered the catch composition and negatively impacted the commercial fish species. More than 3 million seabream juveniles and 2 million soles juveniles were lost every year as discards which gave at least 30 million LE yearly if they take the chance to live. Besides, the trawlers bring in large quantities of by-catch which comprises juveniles of quality fishes, small sized non targeted fish species and crabs. Responsible fisheries at Bardawil lagoon became an urgent issue for the Egyptian fishing industry and Egypt's fish exports. Egypt must be develop, improve and enforce its fisheries management system to ensure responsible fisheries, focusing on the sustainable utilization of the fish stocks and good treatment of the aquatic ecosystems.

INTRODUCTION

Fisheries (which includes the management, catching, processing, marketing of fish stocks) and aquaculture (the farming of fish) provide an important source of food, employment, income and recreation for people throughout the world. Millions of people depend upon fish for their livelihoods. Destructive fishing practices like bottom trawling waste more than 16 billion pounds of fish and kill countless marine mammals every year, while obliterating ocean habitat like coral reefs and seamounts that can take decades or centuries to recover (FAO, 2007).

Bottom trawling, produces large amounts of by-catch, some of this by-catch may be retained and landed and the other part is usually discarded. Discards usually constitute dead fish or other unwanted catch. By-catches impact on the ecosystem by increasing the mortality of the incidentally captured species and have an economic impact when consisting of juveniles of commercially valuable species and food fish and hence constitute a threat to food security and sustainable fisheries. By-catches are generally unregulated and may pose a threat to species diversity and to endangered species, and to the balance and health of the ecosystem. In addition bottom trawling also affects the ecosystem by its physical impact on seabeds and bottom habitats.

Shrimp bottom trawling which locally name kalsa was introduced to Bardawil lagoon by 1995. It is operating at the beginning of the fishing season (April, May, June and July), but now this period was restricted to only two months, April and May. Use of small-sized cod ends in trawl nets result in landing a sizable quantity of small fishes and juveniles especially of seabream and soles. So the main objectives of the present study are to investigate the negative impacts of bottom trawling on the economic and ecosystem of Bardawil lagoon and to reduce overall by-catch by bottom trawlers, in particular the capture of juveniles of commercially valuable species by suggesting alternative fishing technologies of less dangerous impacts on the lagoon fisheries.

MATERIALS AND METHODS

Bardawil lagoon (Fig. 1) is a shallow hyper-saline lagoon with an average area of about 650 Km^2. It extends to about 90 km length with a maximum width of 22 km, and range in depth from 0.3 to 3 m. It occupies much of the Mediterranean coast of Sinai and separated from the sea by a sandbar that varies in width between 100 m and 1 km. Bardawil was connected to the sea via one small natural inlet at its eastern extremity (Boughaz Zaranik) and two man-made inlets (Boughaz I and II). The fishing in the lagoon is seasonal starting in April and extends to the end of December. The Bardawil lagoon fisheries are operated on a small scale basis, utilizing small boats and limited technology which is comprised of trammel nets, trawl nets, shrimp and crab nets and hook and line.

Fig. 1: Bardawil lagoon

Ten surveys were conducted weekly using the commercial boats along Bardawil lagoon during the fishing seasons 2008 and 2009 to identify the catch composition in the by-catch of trawl net (kalsa). Surveys covered two months each season; April and May where the kalsa now was used only through those two months. Every week, one researcher was joined a daily trawling trip to observe and count the whole by-catch. On average, the daily-trip boat brings about 66 Kg of fish as by-catch per day.

Two hauls were randomly sampled and transported to the lab where the samples were washed, sorted and important species of fishes were identified. The length frequency data of the identified groups were collected and the target species were counted and weighed. Also, the presence of any non-target species was recorded and total length of each non-target fish was measured.

The mean number and weight of each species per day per boat were raised to the whole trawling period (60 days) and to the half number of trawlers (614 boats) to estimate the total annual weight of by-catch from the lagoon.

RESULTS AND DISCUSSION

Description of bottom trawl (kalsa) fishery

The trawl net (kalsa) is used mainly for fishing crustaceans especially shrimp. It consists of two wings and a bag; the length of each wing is about 10 m (it changes from place to place, according to personal judgment) and its height is about 2 m. The head rope of the wing is fitted with floats to keep the bag open; the distance between floats is about 25 cm, while the footrope of the wing is fitted with sinkers of about 25 cm apart which keep the bag creeping on the bottom.

The bag net is about 15 m in length and 8 mm mesh size. The mouth of the bag net has a radius of about 12 m. A total of 1228 fishing boats were used the trawl nets, each net is dragged by two boats, the fishermen throw the net in water, then the boats move to deeper water where the bag is dragged and finally, the two wings and the bag are pulled to one of the boats to collect the catch (Fig. 2).

Fig. 2: Spreading the trawl net in the water

The catch is composed mainly of shrimp (about 50%), crab (about 25%) and rabbitfish (about 5%). Shrimp is sorted according to size into two groups; small shrimp and large shrimp. Small shrimp constitutes up to 70% of shrimp catch attaining a market price never exceed 8 LE/Kg, while the large shrimp is composed mainly of *Penaeus semisulcatus* and *P. japonicus* and attain 25-35 LE/Kg market price.

Our experiment which based on life observation of the kalsa catch proof that this fishing method is the most destructive fishing method in the lagoon and should be immediately banned. An average of 66 kg of under sized fish, non-targeted species and very

small crabs were caught as by-catch daily. Also, an average number of 72 seabream juveniles and 53 soles juveniles were observed as dead in the kalsa catch (Table 1)

It is worth mentioning that the shrimp and crab caught by trawl nets have lesser prices than those caught by shrimp and crab nets (the price of crab in kalsa is 2 LE/Kg and is 10-15 LE/Kg in crab nets while the price of large shrimp caught by shrimp net reaches 50 LE/Kg). From the socio-economic point of view, prohibition of kalsa will not have any negative impact on the fishermen. In contrast, this will improve the lagoon ecosystem and fish habitat and reducing the mortality of fish fry and juveniles.

Also, traps could be introduced to catch crab, the design and number of traps should be based on a scientific basis as well as the fishermen who will use these traps not allowable to use any other fishing methods. This will reduce the total effort exerted into the lagoon and will increase the gross revenue as the crab caught by traps will be heavier, bigger and have a high market price.

By-catch Composition

The major species in Kalsa (trawl) by-catches were gilthead seabream juveniles, soles juveniles, groupers, glass eel, *Terapon puta*, *sardinella aurita*, *Atherina*, and others like shells, gastropods, jelly fish, squilla, small crabs and small sized non targeted fish (Fig. 3). A trawler operating in the lagoon lands about 66 kg of by-catch per two boats per day, on average. Some of the by-catch may be retained and landed like rabbitfish, other sparid species, sardine, eel and small groupers. For this landed part of by-catch the price not exceed 5 LE per kg. Another part is usually discarded, i.e. returned to the lagoon. Discards usually constitute dead fish or dead small crabs or other unwanted catch. The juveniles of highly commercial fish species constitute the mainstay of the discarded portion.

Since fish production in Bardawil lagoon has reached its maximum sustainable level and all fish stocks have been overexploited (Mehanna, 2005, Mehanna *et al.*, 2010), the need of the hour is to utilize the resource judiciously. By-catch is an inevitable outcome of trawl fishing and it should be properly managed for better returns from the fishery. Globally, there is now an emphasis on reducing the by-catch through increasing the cod end size to the recommended 40 mm and use of square mesh cod ends. This will help in conserving the fishery resources, particularly the commercially important species.

Economic impacts

In the past, bardawil lagoon was an important source for the high quality fish species (seabream, seabass and soles) and a principal pillar in Egypt's fish exports where the bulk of its fish production was exported to Europe (Ben-Tuvia, 1985), while a small portion goes for fresh consumption. By the day the seabream, seabass and soles stocks in the lagoon are heavily exploited (El-Gammal *et al.*, 1994; Khalifa, 2005; Mehanna, 2006; Mehanna *et al.*, 2010; Abd-Elhakim *et al.*, 2010) and their catches showed a serious decline. Only 314 ton of seabream were landed in 2009 compared with 1804 ton in 1982, while only 80 ton of seabass were landed in 2009 compared with 186 ton in 1990. One of the main causes of stocks depletion in the Bardawil lagoon is the introducing of bottom trawl nets. More than 3 million seabream juveniles and 2 million soles juveniles were lost every year. Recruitment of juvenile seabream and soles generally takes place during April–June, so they are vulnerable to the bottom trawl in large numbers. These juveniles have no commercial value and therefore totally discarded at sea. Also, a lot of undersized fishes and crabs which do not fetch good prices were caught as by-catch. Generally, the fishing activity addressed to the catch of certain species produces undesired mortality to many less valuable species. The mesh size currently used in the bottom trawl nets is 8 mm (global legal mesh size is 40 mm

and totally prohibited in the shallow areas) defines a very low probability of retention for small-sized individuals.

The minimum market size for seabream is 300 g with prices reach 70 LE while for soles the minimum market size is 200 g with prices reach 55 LE. During the surveys, an average number of seabream juveniles of 72 juveniles per day per two boats were recorded with weights ranged between 1 and 25 g but the majority didn't exceed 10 g. For soles, 53 juveniles per day per two boats were counted with weights varied from 3 to 15 g but the majority didn't exceed 6 g. If the half of this number has the chance to grow up and reach the market size, it will be achieving at least 30 million LE yearly (with mean market prices of 50 LE per Kg for seabream and 35 LE per Kg for soles) (Table 2).

Habitat impacts

Bottom trawling not only impacts the seafloor but also changes the ambient water quality due to the disturbance of nutrients and sediment settled on the seafloor (Palanques, *et al*. 2001). The short-term impacts of trawling on benthic communities (infauna and epifauna) include physical damage to benthic organisms; direct mortality of vulnerable species; reduction in diversity and abundance of some taxa; increase of scavengers and other opportunistic species in disturbed areas (Sanchez, *et al*. 2000; Simpson, 2003; Stone, *et al*. 2005).

During surveying Bardawil lagoon, it was noticed that there is a great change in the macrobenthos structure of the lagoon and a huge flourishing for seagrasses and seaweeds. Seagrasses provide shelter and nursery areas for tiny worms, echinoderms and crustaceans especially for shrimp. This leads to the appearance and predomination of crustacean species in the lagoon. By the day shrimp and crab forming more than 60% of the lagoon catch (GAFRD, 2010). Fishar (2005b) mentioned that the standing crop of total benthos during 1984 was 4164 organisms/m^2 decreased to 3711 organisms/m^2 during survey of 1986–1987 and continues their decrease in 2003 (2230 organisms/m^2) followed by a sharp drop during 2004 (359 organisms/m^2). In 2003, the species composition of macrobenthos changed dramatically. Nine annelids and 3 molluscs species were disappeared accompanying by the appearance of three arthropods, one nemartine species, one echinoderm and one coelenterate species (El-Shabrawy and Khalil, 2003; Fishar, 2005a; El-Shabrawy and Rizk, 2005). Changes in fish community due to introducing bottom trawl affects macrobnethos assemblages, since the declined fish species are mainly bottom feeders. As an instant, Mollusca comprised the highest volume of *Sparus aurata* diet. It formed up to 33% and was found in 90%, while Crustaceans constituted about 8% by volume (Khalifa, 1995). In contrast, the seabass is a predator, consuming small fish and a large variety of invertebrates especially shrimp and crab which constitute up to 70% of seabass meal (Abdel-Hakim, *et al*. 2010). Accordingly, the decrease of predators leads to reduction of the grazing pressure upon the prey, and in turn increase and flourishing of the prey.

Responsible fisheries management of Bardawil lagoon

In recent years, measures have been taken in strengthening an ecosystem approach to the fisheries management. Increasing emphasis is placed on research and development of methods in this field, and on fisheries advice that takes into account various interrelated factors in the ecosystem, such as the interaction of the species, environmental change and multi-species impacts. The focus is furthermore on strengthening research on the effects of fishing gears on the ecosystem, particularly on the seabed and the living bottom communities.

Several regulations were enforced by the General Authority for Fish Resource Development (GAFRD) for the general management of the lagoon. The beach-seine was

prohibited, fishing was forbidden during the winter months; from the beginning of January to early April and the number of purse-seines operating in the lagoon has been decreased. They also maintaining and dredging the two Boughazes continuously. Moreover, six cooperative societies were established for about 4200 fishermen working in the lagoon. They provide motors, spare parts, fishing equipment and market the fish for their members who submit their production to the societies.

Unfortunately, these regulations couldn't ensure the sustainability of the lagoon and the conservation of commercial fish stocks. The lagoon management plan should be developed and improved based on the following measures:

- Further investigation on different fishing gears and their impact on the lagoon ecosystem, including bottom trawl, line, trammel net and crab net and on the fishing gear's selectivity.
- Kalsa or bottom trawl must be totally prohibited and replaced by traps and set nets for catching crab and shrimp
- Deciding the total allowable catch (TAC) where every species in the lagoon should be subjected to quota regulation. A scientific assessment of the state of the fish stocks and the condition of the ecosystem constitutes the main basis of determining the TAC each year. This measure should be based on effective monitoring and enforcement of the fisheries and the total catch.
- Protecting fish juveniles, under sized fish and the ecosystem through the regulations on the type of fishing gear allowed in different areas, the closing of fishing grounds, using of small-fish sorting grids and controlling the mesh sizes.
- Strengthening of Fisheries' societies and improved Community participation
- Improving the fishery statistics recording system and introducing the new technologies in recording system to ensure transparency. Also, these statistics should be accessible to all.

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Fig. 3: By-catch composition from two different hauls

Table 1: Crustacean catch and by-catch of bottom trawl as observed through ten weeks.

Week	No. of haul/day	By-catch			Small shrimp (kg)	Large shrimp (kg)	Crab (kg)
		No. of Seabream juveniles	No. of Soles juveniles	Wt. (kg) of Small sized fish			
1	19	158	67	45.5	58.5	13	33
2	16	103	45	40	43.5	13	24
3	21	50	41	59	70	19.5	40
4	18	34	35	62	68	12	51
5	20	62	59	65	90	10.5	60.5
6	19	64	54	49	41	30.5	64
7	21	117	54	78	79	36.5	70
8	24	58	39	88	121	46.5	64
9	22	26	61	73	73	42	49
10	30	47	72	103	124	45.5	84
Mean/ day/boat	21	72	53	66	77	27	54
Total season (Kg)		2966.4	2039.4	2431440	2836680	994680	1989360

Table 2: Different scenarios showing the negative impact of bottom trawl (kalsa) on Bardawil lagoon fisheries.

Item	Seabream	Soles
No. of juveniles	2652480	1952520
Market minimum size (kg)	0.3	0.2
Market price (LE)	70	55
Money lost with 100% survive	55702080	21477720
Money lost with 50% survive	27851040	10738860
Money lost with 50% survive and lesser prices (50&35 LE for both species respectively)	19893600	6833820

دراسة تأثير حرفة الجر القاعية المستخدمة لصيد الجمبرى على مصايد بحيرة البردويل-مصر

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يعتبر قطاع المصايد من القطاعات الهامة للاقتصاد المصري حيث يوفر فرص كبيرة للعمل وخاصة في المجتمعات الساحلية كما يعتبر مصدر غذائي متجدد ومصدر هام من مصادر البروتين الحيواني كما أنها موردا للعملة الصعبة نتيجة التصدير. تعانى مصايد مصر الطبيعية البحرية منها والداخلية من الاستغلال الجائر للمخزونات السمكية بها مما يستوجب إدارتها ادارة رشيدة. يعتبر الصيد الجائر والنشاط الإنساني المتزايد على المناطق الساحلية الذى اثر بالسلب على البيئة المائية من أهم العوامل التي أدت الى التناقص الحاد في المخزونات السمكية في المصايد المصرية. تعتبر بحيرة البردويل من أهم بحيرات مصر الشمالية حيث أنها أقل البحيرات تلوثا ليس في مصر فقط بل في منطقة البحر المتوسط ككل كما أن معظم انتاجها من الاسماك كان يتم تصديره. كان لاستخدام حرفة الجر القاعية والمعروفة محليا باسم الكلسة فى هذه البحيرة الضحلة أثار مدمرة على الثروة السمكية والبيئة المائية للبحيرة. تفقد البحيرة سنويا ما يزيد على ٣ مليون زريعة دنيس و٢ مليون زريعة موسى الى جانب كمية كبيرة من الاسماك صغيرة الحجم عديمة القيمة الاقتصادية تصل الى 66 كجم في اليوم الواحد مما يتسبب في خسارة تعدى الثلاثين مليونا من الجنيهات سنويا على أقل تقدير. لذلك أصبح من الضروري أدارة البحيرة ادارة رشيدة لتحقيق العائد الاقتصادي المرجو منها وزيادة حجم الصادرات من أسماكها. كما يجب تطوير وتحديث ومتابعة المعايير التنظيمية الحالية المتبعة فى المصايد المصرية بحيث تعتمد على النظم البيئية متكاملة وعلاقة الكائن بالبيئة التي يعيش بها بما يضمن الاستغلال الامثل مع الحفاظ على هذه البيئات والتوازن الطبيعي بها.